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FORAGE AND GRAIN PRODUCTION OF DUAL PURPOSE TRITICALE GROWN UNDER MOROCCAN CONDITIONS

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ABSTRACT

The use of triticale for feed is expected to be increased depending on the release of suitable varieties. The main objective of this study was to identify productive and suitable triticale material intended for dual purpose use under Moroccan climate and soil conditions. 50 advanced accessions of hexaploid triticale were tested for vigor, earliness, biomass and grain yields. Selected accessions were compared to barley, rye and triticale cultivars for forage and grain productions. Field trials were conducted at El Koudia farm in Morocco (34°03' N, 06°46' W) with varying defoliation regimes (uncut to grain yield, cut at erect leaf stage and cut prior to last leaf emergence. Yielded dry matter ranged between 0,96 and 2,74 t ha^{-1} respectively for early and delayed cutting. Four accessions yielded high forage such as barley, rye and triticale cultivar Juanillo. Forage removal had a depressive effect on grain yield for which losses reached 11% for early clipped genotypes and were of 32 to 73% when accessions were defoliated later. Grain and straw yield losses reported to forage harvested at vegetative stage indicated that genotypes E12, E18, E19, E20, Juanillo and barley cultivars gave the best compromises and were the most adapted to clipping.

***KEYWORDS:** Triticale, Dual Purpose, Forage Production, Grain Yield, Clipping & Vegetative Stage*

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Original Article

INTRODUCTION

The use of cereals for livestock grazing at early vegetative growth stages is traditionally practiced in Morocco mainly for barley [2]. It is conceived as a valuable tool to fill winter feed gaps without compromising yield. Barley, oats, wheat and triticale are all used as dual-purpose cereals in Mediterranean region, characterized by its mild winter and dry spring [22]. However, wheat is less preferred than the other cereals [11].

Several studies quoted that winter and spring triticale varieties are suitable for dual-purpose use, since triticale can produce a large amount of biomass and recover after grazing to produce grain for a summer harvest [7 ; 12 ; 23 ; 22]. Besides being used for dual-purpose, triticale cultivars are increasingly sown instead of other dual-purpose or grazing cereals, particularly in areas where environmental conditions limit the productivity of oats, barley and wheat [13]. They have superior or equivalent dry-matter production capacity combined with better resistance to foliar diseases and tolerance to drought, acid soils and water logging [5].

Suitability to dual-purpose practice is defined by the biomass productivity before grazing and the subsequent grain yield after re-growth. The good management of grazing or cutting is the best way to establish a

right balance between feed and grain. In fact this balance depends on the whole crop management, soil fertility and moisture but mainly on genotypes [19].

Defoliation during early growth stages could increase seed yield and forage quantity and quality [10; 22]. Indeed, grazing of dual-purpose triticale before erected leaf sheath stage (GS30) had little or no effect on yields if appropriately managed in high and medium rainfall zones [14]. Adding to this, early grazing could even result in yield increase by preventing cereal lodging as for barley [8]. Conversely, it has been reported that defoliating (grazing or cutting) triticale at vegetative stages, compromise tiller number, stem elongation, leaf and root growth and influences the subsequent grain yield, by reducing ears number per m ² and green leaves before anthesis stage [3 ; 4 ; 9 ; 12]. Forage grazing or clipping should be stopped before jointing stage (GS31) to prevent serious grain yield decrease [23]. Indeed, grazing or clipping forage beyond jointing stage result in apical buds removal and leaves regeneration is insured by the remaining less productive tillers [16]. While the capacity to produce new photosynthetic tissues and an enhanced tiller survival are the main characteristics required when selecting new cultivars dedicated for dual-purpose. Even different studies were undertaken through the Mediterranean region, crop management for dual-purpose use is still variable because it depends mainly on the used triticale material.

For these reasons, we aimed through this study to screen triticale nursery for grain and forage productions under Moroccan climate and soil conditions, and select elite material conceived for dual purpose.

METHODOLOGY

Two experimental trials were undertaken over two years. The first trial concerned fifty accessions of triticale advanced material assessed for biomass and grain yields. Selected accessions were compared to 5 registered varieties of triticale:"Juanillo, Drira, Beagle, Borhane and Momtaz", barley Acsad176, and rye Petkus, during the second year.

Both trials were conducted at El Koudia experimental farm (34°03' N, 06°46' W), on a sandy loam and slightly acidic soil (pHw 5,9). Sowing were carried out manually in mid November on prepared seedbed cropped previously with lupine and vetch respectively

Accessions were sown with a density of 300 seeds / m ² in 20 cm spaced 4 rows of 3 m length and in 6 rows of 10 m spaced by 20 cm respectively for both cropping years.

Fertilizers were applied before sowing at rates of 35, 70 and 35 units ha^{-1} of nitrogen, phosphorous and potash respectively. Plots received an additional 40 units/ha of nitrogen in tiller and jointing growth stages.

The first trial was designed according to an incomplete block design with complete replications, containing 50 accessions and 2 replications with 10 incomplete blocks. Each block contained 5 accessions and triticale cultivar Juanillo used as check.

The design of the second trial was a balanced lattice with 5 replications and 4 blocks. Each block contained 4 accessions / cultivars. Within each plot, three strips of respectively 2, 2 and 4 m length were identified after plants emergence and corresponding each to one forage harvest management treatment.

Two harvest managements were performed and consisted in cutting forage at erect leaf stage and at second node stage corresponding to the growth stages: GS 5 and GS 7 according to Feeks scale [17]. Control treatment was maintained without clipping to determine grain yield without forage removal. Cutting reduced plants to 4 to 5 cm height without

removing growth apexes at growth stage 5 but with complete apexes loss when delaying cutting to GS 7. Both cuttings were performed manually for the 4 central rows. Border rows were cut and discarded for plot homogeneity. Trials were kept weed free by frequent hand weeding in both years. All plots were harvested manually in 28th May and mid June respectively and threshed by an immobile threshing machine.

For the first trial, observations and measures concerned early plant vigor and earliness to heading, based on a visual scale from 1 to 9 from the less to the most vigorous accession. Heading stage was scored when at least 50% of plot plants headed. Biomass and grain yields were determined after harvesting and threshing.

During the second year, forage green matter was weighted after each cutting. Samples of 500 g were taken, divided into leaves and shoots and were oven dried at 70°C during 48 hours. A sample of 20 green leaves from harvested forage were passed into electronic leaf area meter (Licor 3000), dried and weighed to determine LAI (leaf area index) according to the formula: LAI=SLA x (L/L+S) x DM. (SLA: specific leaf area; L: leaf; S: shoot, DM: dry matter). Growth stage development was monitored at regular interval on 5 plants randomly chosen to determinate the appropriate cutting time according to Feeks scale [17].

Statistical analyses were made by SAS software according to the GLM Procedures for incomplete block design with complete replications and for balanced lattice design respectively (SAS institute, 1990). Analysis of variance of all the data was performed according to both designs. Least significant difference values were calculated at the 0.05 % level of probability to separate treatment means.

RESULTS AND DISCUSSIONS

Climatic Characterization

Annual rainfall was of 714 mm and 611 mm respectively for the first and second cropping years. Maximal and minimal monthly average temperatures for both cropping seasons varied from 16 to 23 °C. For the first and second years, it ranged between 6 to 15 °C and 14 to 25 and 5 to 15 °C respectively (figure 1).

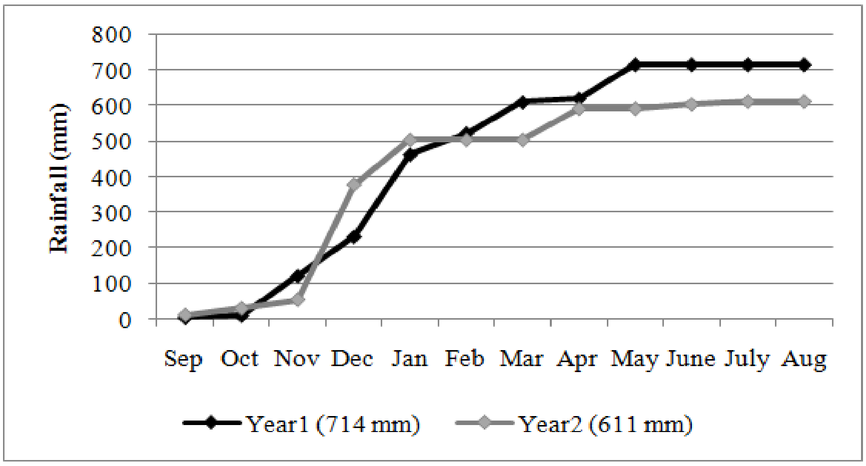

Figure 1: Cumulative Rainfall during the Two Growing Seasons of Experimentation at El Koudia, Morocco

Most accessions performed a good vegetative growth under field conditions in Morocco and showed good vigor. Significant differences were revealed ($P<0.01$) within the fifty accessions tested during the first year. Average yields were of 1.48 and 0.33 kg/m² for both biomass and grain yields respectively (figure 2). 54% of the accessions exceeded the

average grain yield whereas 42% of accessions yielded high biomass above the average. Significant correlation ($r = 0.22$, $p < 0.05$) was found between vigor and biomass yields.

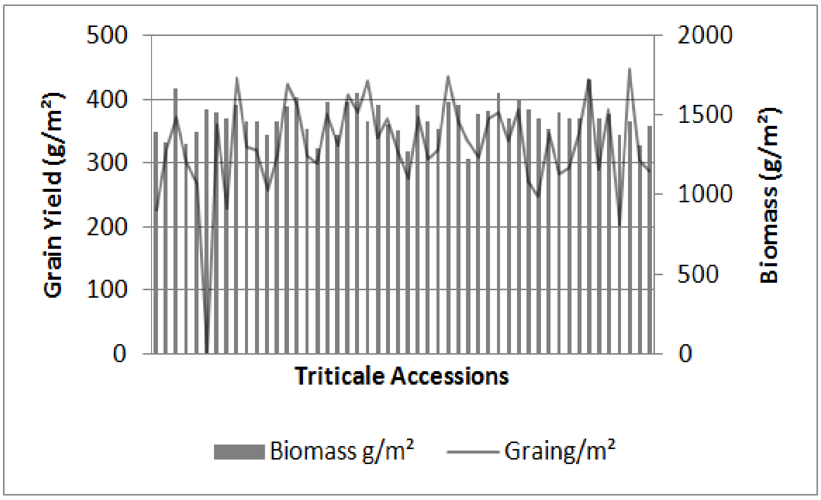

Figure 2: Biomass and Grain Yields (g/m²) of Fifty Triticale Accessions under Field Conditions (El Koudia, Morocco)

Suitability for Dual Purpose

Accessions were plotted according to their grain and biomass yields (figure 2). Indeed the two criteria are commonly used to differentiate accessions and cultivars according to their own vocation [24].

Accessions which yielded more than trial average for both grain and biomass were considered as double purpose material per se grain and forage. Those whose grain yields were lower than the average grain yield were considered as feed accessions. While, grain accessions were those whose grain yields outrun grain yield average. Accordingly, the tested accessions were divided in four groups as follows: 6 accessions for grain production, 18 accessions for biomass production, 18 accessions for double use and 8 accessions considered without interest in forage production (figure 3).

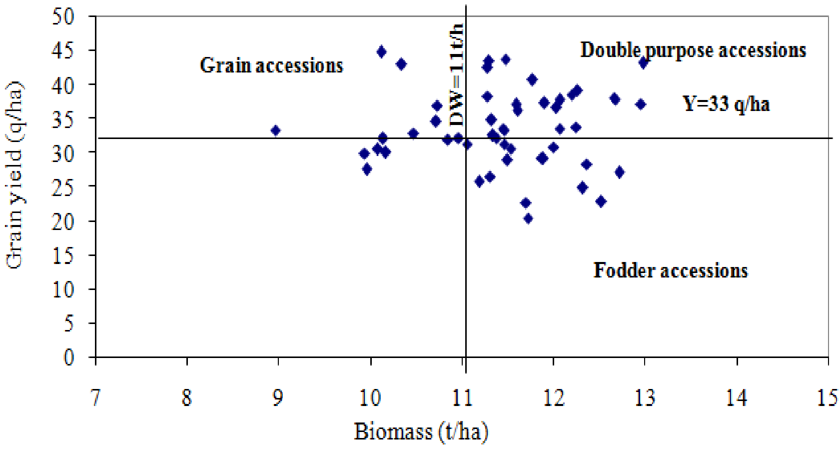

Figure 3: Biomass (ton ha $^{-1}$) and Grain Yields (0.1 ton ha $^{-1}$) of 50 Triticale Accessions Tested at El Koudia, Morocco

From the accessions suitable for double purpose, nine were selected and compared with five registered cultivars of triticale and one cultivar of barley and rye during the second cropping year under field conditions.

Forage Yield

Forage yields averaged 0.96 and 2.74 t ha^{-1}, for the cutting at GS 5 and GS 7 respectively. Significant differences were shown (P<0.01) through accessions and cultivars (figure 3). Four triticale accessions yielded high amounts of early forage as barley, rye and Juanillo cultivar.

Harvested forage biomass was increased by 65 % when cutting was delayed from tillering to jointing stage, due to plants growth progression. Tiller number per plant was increased by 40 % compared to that of the early cutting stage. Furthermore, delayed clipping had resulted in 29% increase of leaf area index (LAI). Differences were shown within cultivars and accessions (P<0.01) for this trait. High correlations were found between LAI and biomass yields for early (r= 0.88) and delayed cutting (r=0.58) (P<0.01). Significant differences had been found through genotypes

The observed variability through genotypes suggest that cut or grazed biomass at vegetative stages could be considered as interesting trait for selecting material for early vegetative defoliation [1].

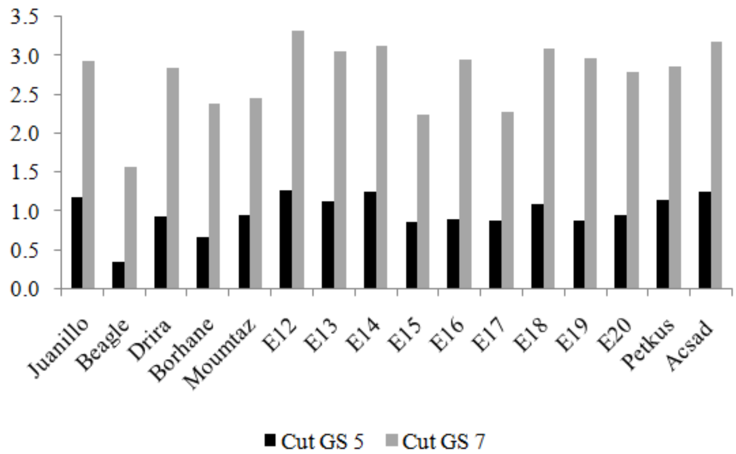

Figure 3: Forage Yields (t ha^{-1}) of Triticale Accessions and Two Varieties of Barley and Rye Harvested at Vegetative Stages GS 5 and GS 7

Grain Yield

Cutting forage at vegetative stages had a depressive effect on the subsequent harvested grain yields. Drastic yield drops had been registered when cereals were defoliated at jointing stage (GS 7). Yield reductions varied from 32 to 73% compared to unclipped treatment (Figure 4). Nevertheless, grain yield loss was about 11% for genotypes clipped at GS 5.

Lodging and diseases contributed to yield losses and resulted in some yield variability for both cut and uncut treatments. It is assumed that grazing or harvesting forage at early vegetative stages can be made without compromising further grain yields only in absence environmental stresses [6].

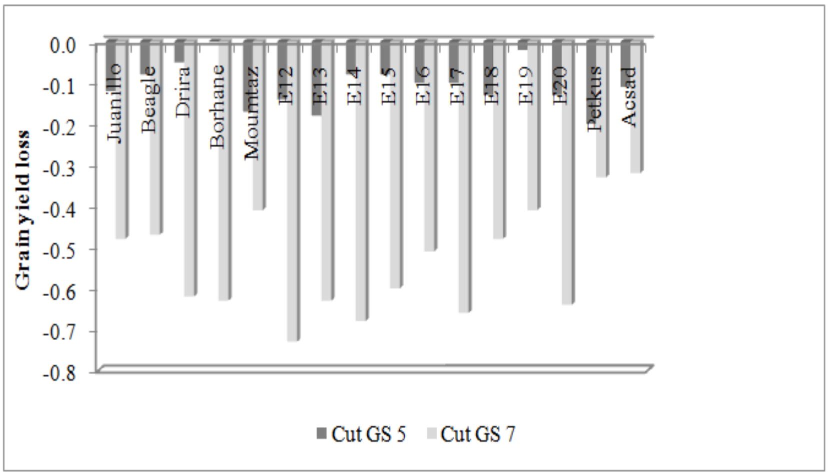

Figure 4: Grain Yield Loss Engendered after Cutting at Two Vegetative Stages of Triticale, Barley and Rye Cereals

Both cuttings reduced grain yield for accessions and cultivars excepting Borhane cv, where the early cutting did not affect final grain yield. However, delayed cutting to GS 7 engendered a drastic grain yield decrease compared to earlier cutting (GS 5). Yield losses averaged 54 % and 11 % respectively compared to uncut treatment. These results confirm that the jointing stage is a critical stage for grazing or cutting forage as reported by [6].

Grain yield reduction is mainly due to the decrease of thousand kernels weight. This yield component which is characteristic for varieties was widely affected by early forage cutting. Besides, water status and temperature were also involved in yield reduction. Indeed, both cuttings delayed flowering occurrence of 3 and 6 days respectively. This delay resulted in a gap of the grain filling period which coincided with high temperatures.

Straw yield was reduced significantly for both cutting ($P<0.01$). Average straw losses reached up to 21% and 43% respectively for early and delayed cutting compared to uncut treatment. Triticale accessions E12 and E19 did not undergo big straw losses, while barley and rye cultivars showed intermediate straw losses after early and delayed defoliation. Straw yield reduction was mainly due to plant height decrease at harvest time, engendered by plant cutting but also some plants degeneration. These trends of decrease were also reported by [18 ; 15 ; 8].

Forage and Grain Compromise

Practical profitability of clipping or grazing forage in early vegetative stage, should take into consideration the amounts of provided early forage with the grain and straw yields at harvest time, but also the loss of the grain and biomass yields engendered by the early defoliation. An appropriate balance must be established between these two outcomes.

When clipped at GS 5, triticale accessions: E13, E14, E15, E18, E19, and cultivars Borhane, Beagle and Petkus rye combined good grain and straw yields, with higher biomass at vegetative stage. Barley cultivar could be added to this material despite its low grain yield, imputed to sparrows' grain shelling as a purely physical phenomenon.

According to grain and straw yield losses reported to amounts of forage harvested in early vegetative stage (table. 1), triticale accessions E19, E12, E20, Beagle and Moumtaz, registered less grain and straw yield losses compared to early earned biomass. For these genotypes, each ton of early clipped forage generated loss of 0.5 to 1.5 ton of biomass (grain and straw) at harvest time. Besides, biomass production of accession E19 was improved by early clipping at GS 5.

When delayed to GS 7, clipping resulted in total extermination of plants buds, which hampered convenient regeneration of plant tillers. This affected strongly the subsequent grain and yield productions. Furthermore, losses of straw and grain engendered by delayed defoliation compared to forage amount won were important and hardly seem to compensate for yield losses. Nevertheless, accessions E12, E19, E18, Juanillo and Moumtaz triticale, Petkus rye and Acsad barley, registered significant lesser decrease.

Accordingly, to tested genetic material performances against both early and delayed clipping and in the condition of the trial, triticale accessions: E12, E18, E19, E20, Juanillo, Acsad176 barley seems to be adapted to clipping in vegetative stages of growth.

Table 1: Biomass Losses (Grain and Straw) Reported to Amounts of Forage Harvested in Vegetative Stages

Accessions and Cultivars	Straw and Grain Loss/Harvested Forage (T) at GS 5	Straw and Grain Loss/Harvested Forage (T) at GS 7
Juanillo	2,92	2,27
Drira	1,92	4,29
Beagle	0,84	3,28
Borhane	2,76	4,76
Moumtaz	1,21	2,31
E12	0,50	1,35
E13	3,40	3,62
E14	2,22	3,16
E15	2,47	4,09
E16	3,12	2,75
E17	3,74	4,21
E18	2,27	2,33
E19	-0,25	1,47
E20	1,53	2,76
Petkus	2,83	1,80
Acsad176	1,85	2,43
Mean	2,08	2,93
Lsd	0,324	0,298

CONCLUSIONS

Triticale cereal confirmed its high potential for biomass and grain productions as the other small grain cereals. Nine accessions showed a double purpose use by producing good levels of both biomass and grain yields. Accessions: E12, E18, E19, E20, Juanillo triticale and Acsad 176 barley showed a better performance as dual purpose genotypes. Forage amounts harvested at vegetative stage were important and suitable to fill the gap of winter forage scarcity. However, grain yields decreased with clipping in early vegetative stages, especially in growth stage GS7. Plant regeneration was affected when apical buds were suppressed by clipping. Many yield components were affected by clipping, which explained the high grain yield decrease compared to uncut crop. New triticale accessions: E12, E18, E19, E20, Juanillo triticale and Acsad176 barley seem to be more adapted to dual purpose management and presented a reasonable compromise between forage and grain use.

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